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N7T1B
G4N NCM N2A2

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Measurement, Vol 44 No 3, June 1995, pages 743-746

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(54) Abstract Title

Electronic pedometer, expected behaviour detector and security system

(57) An electronic pedometer comprises a motion detector (2) connected to a data processor (12). The pedometer is provided in an article which is carried and so the motion detector operates in 3 axes such that the device cannot be defeated by carrying it the wrong way up. The data processor counts the number of steps taken and may also identify the person carrying the container from his walk. If too many steps are taken or the persons walk is not recognised, then a security system in the container is activated.

FIG. 1

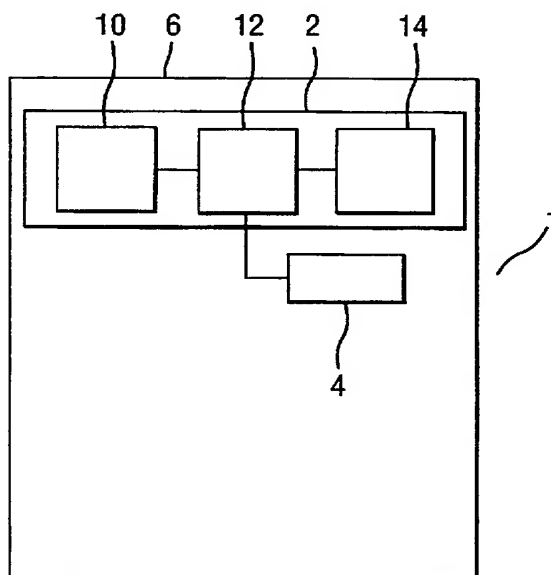


FIG. 1

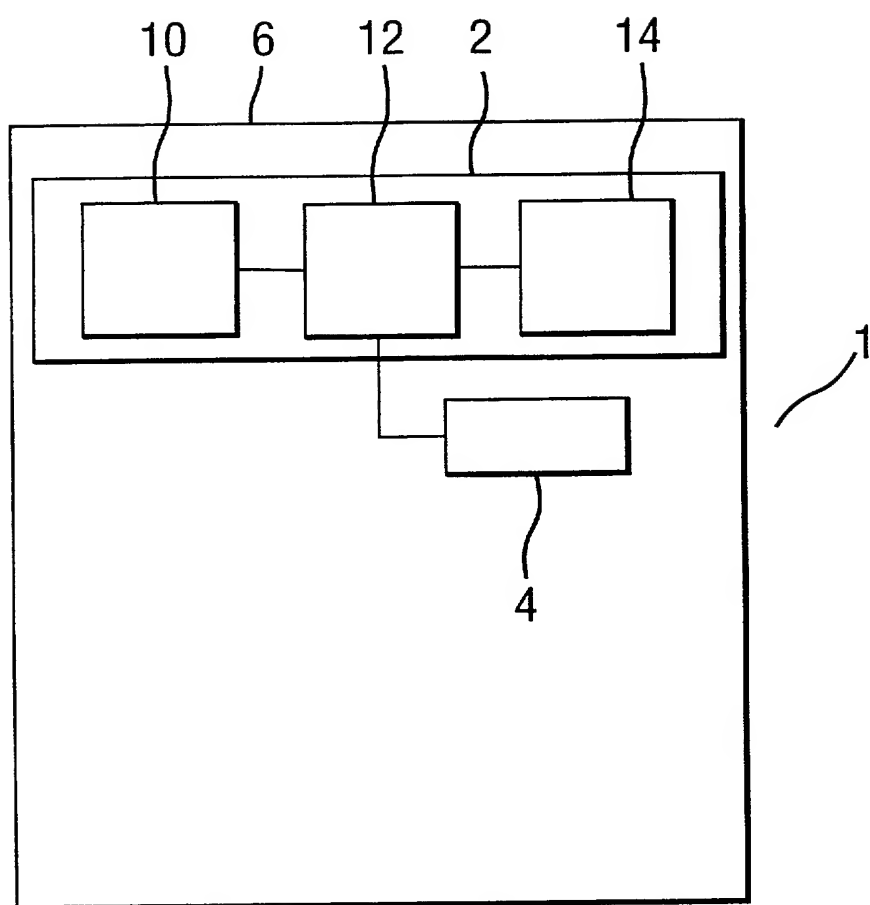
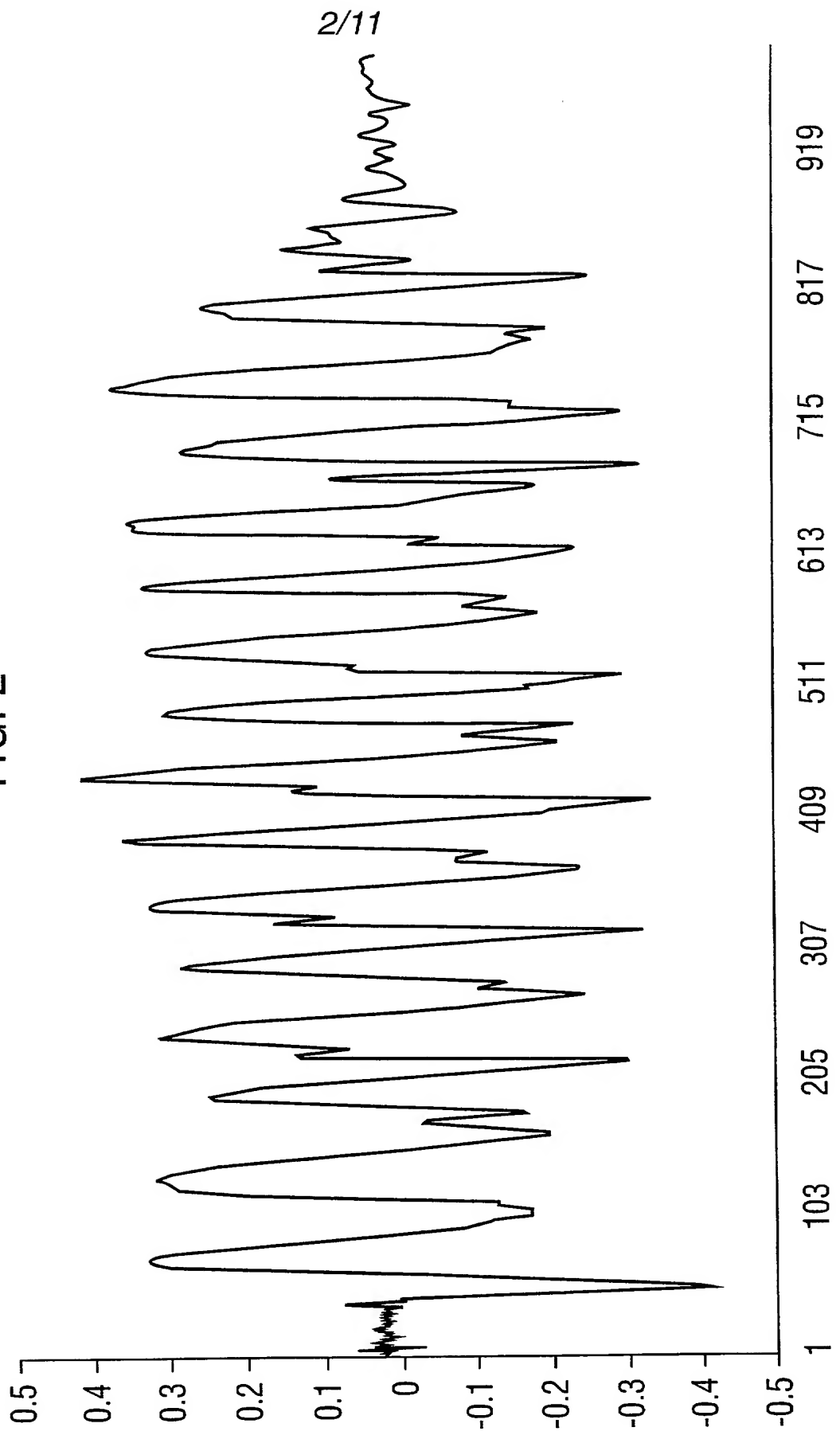


FIG. 2



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FIG. 3

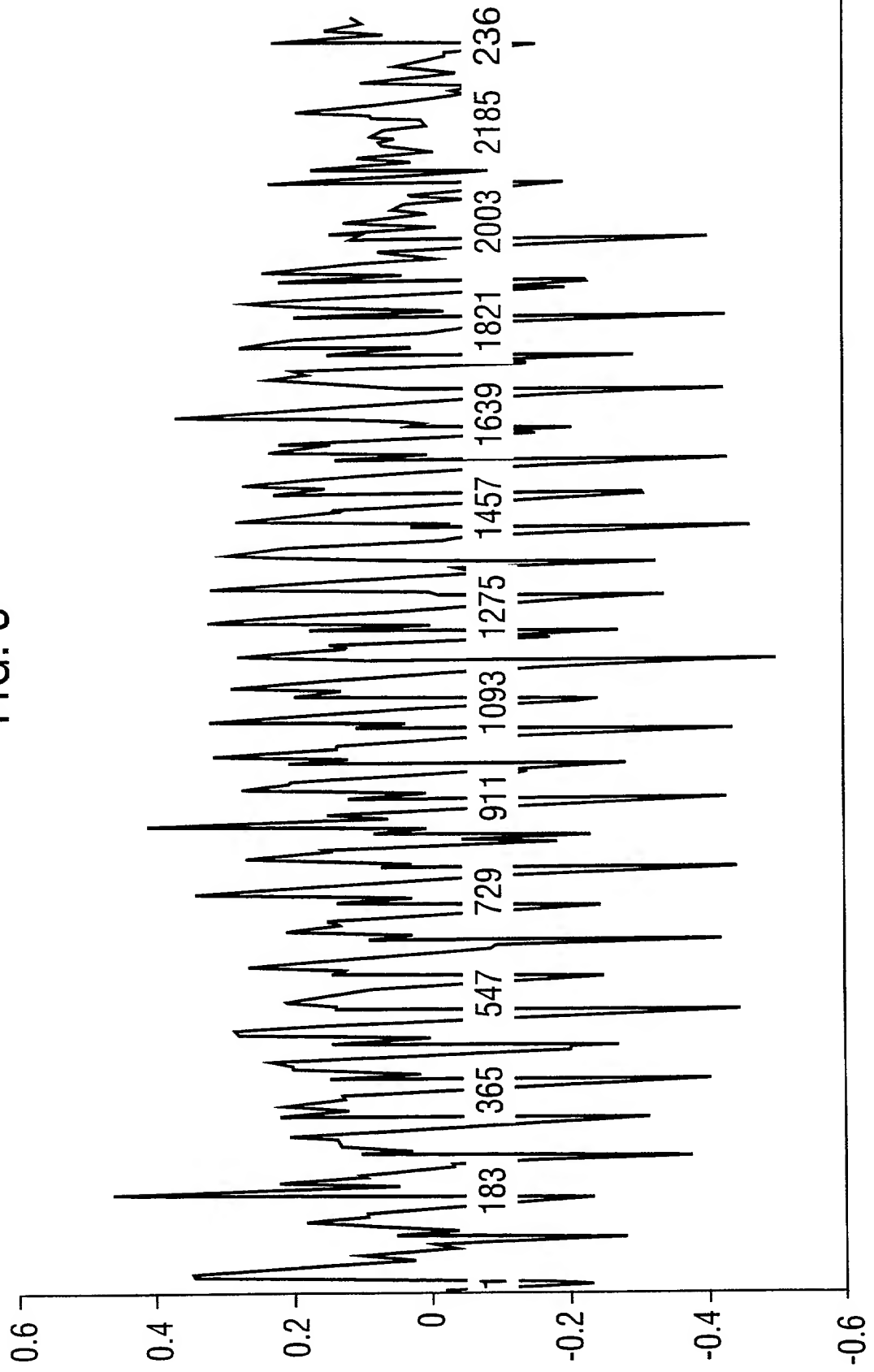


FIG. 4
AUTOCORRELATED WITHOUT END EFFECT

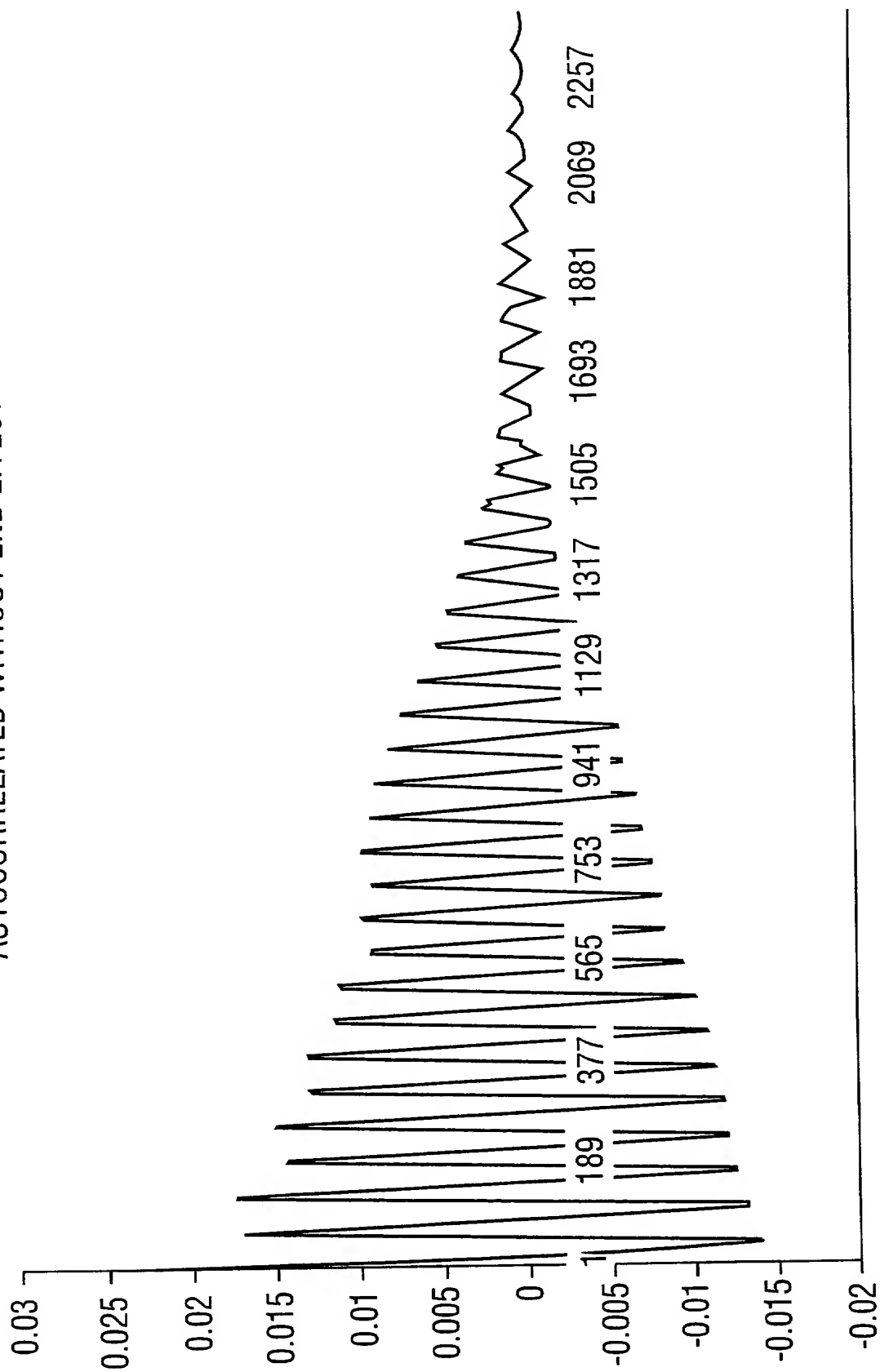
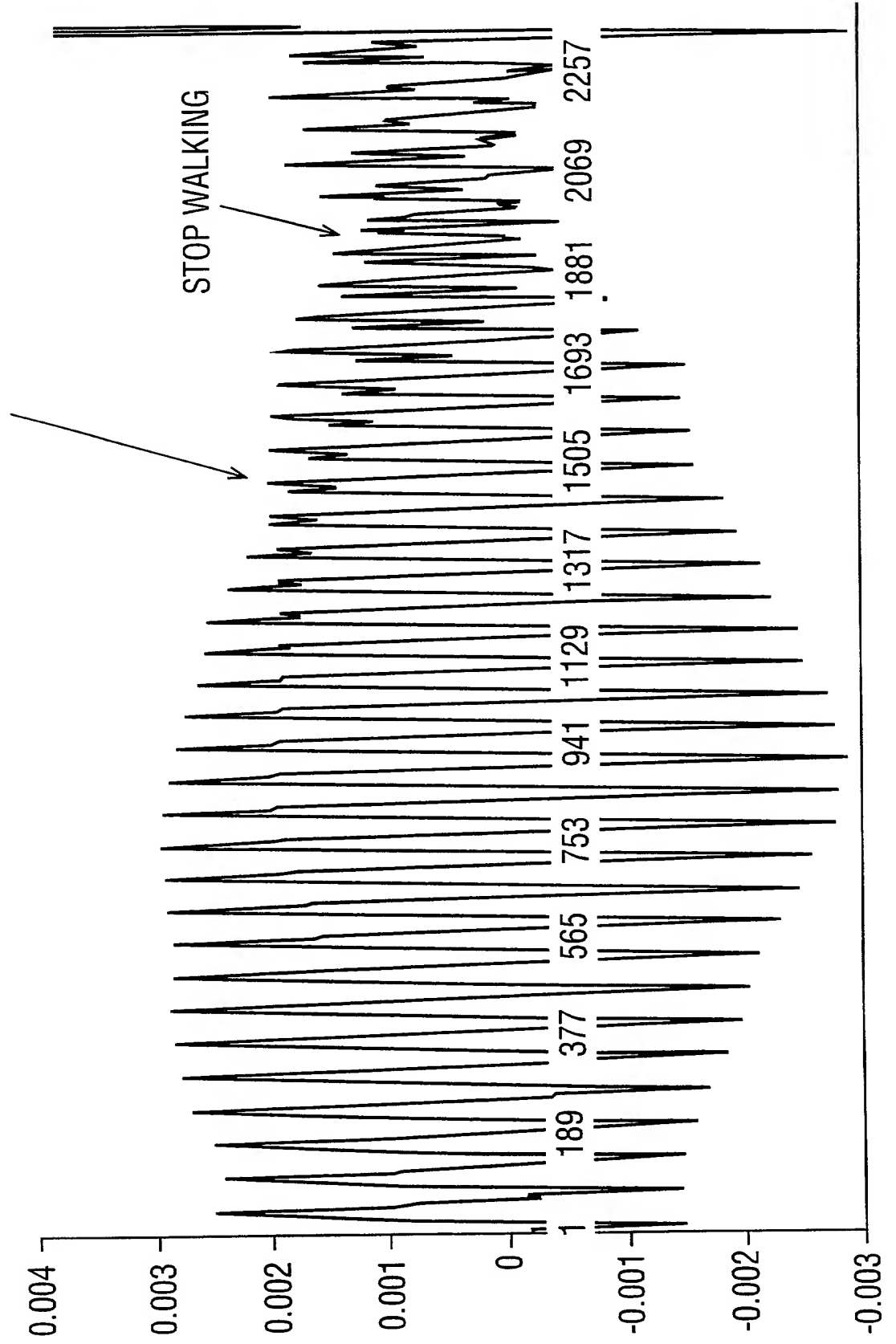


FIG. 5
641ma30.txt



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FIG. 6

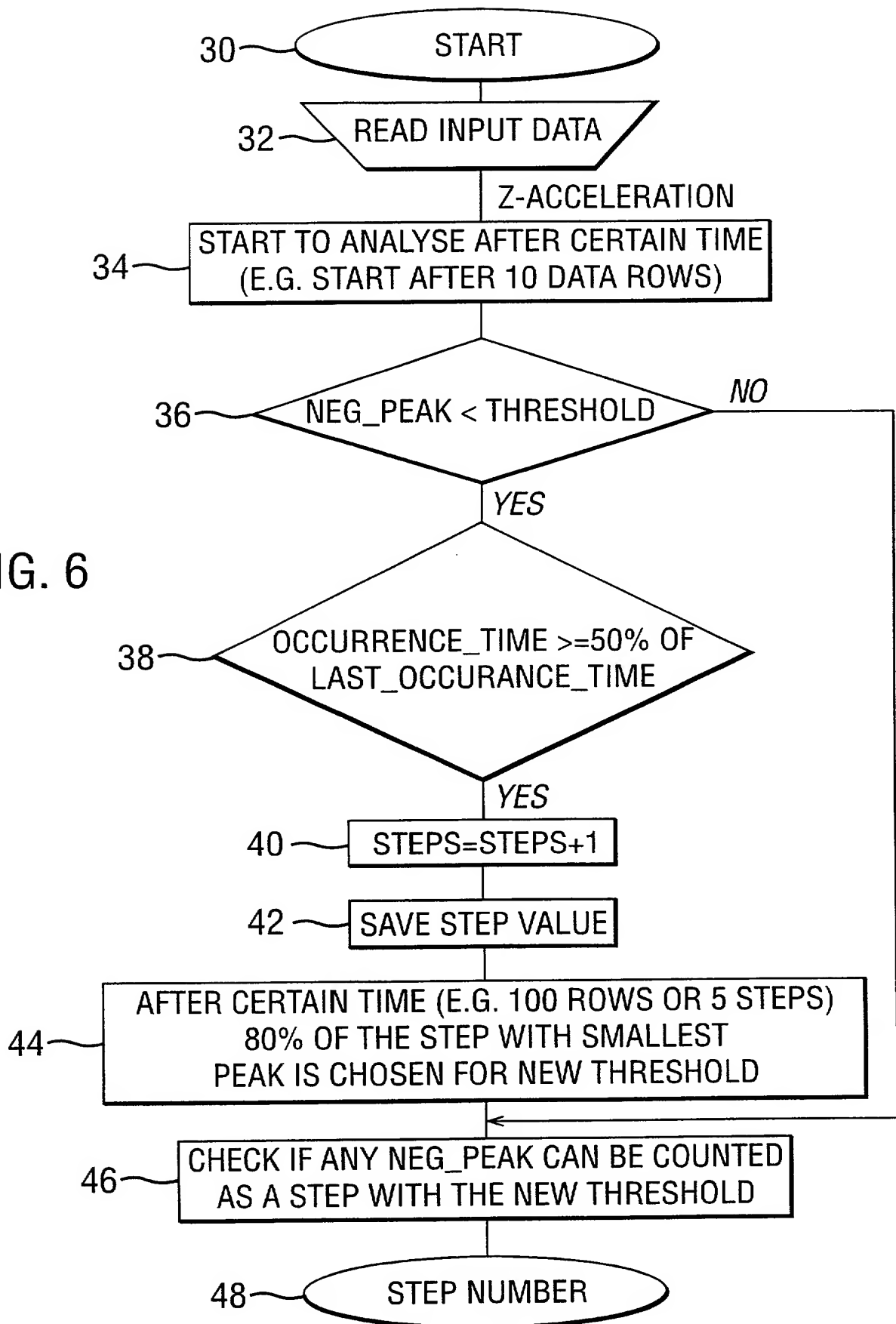
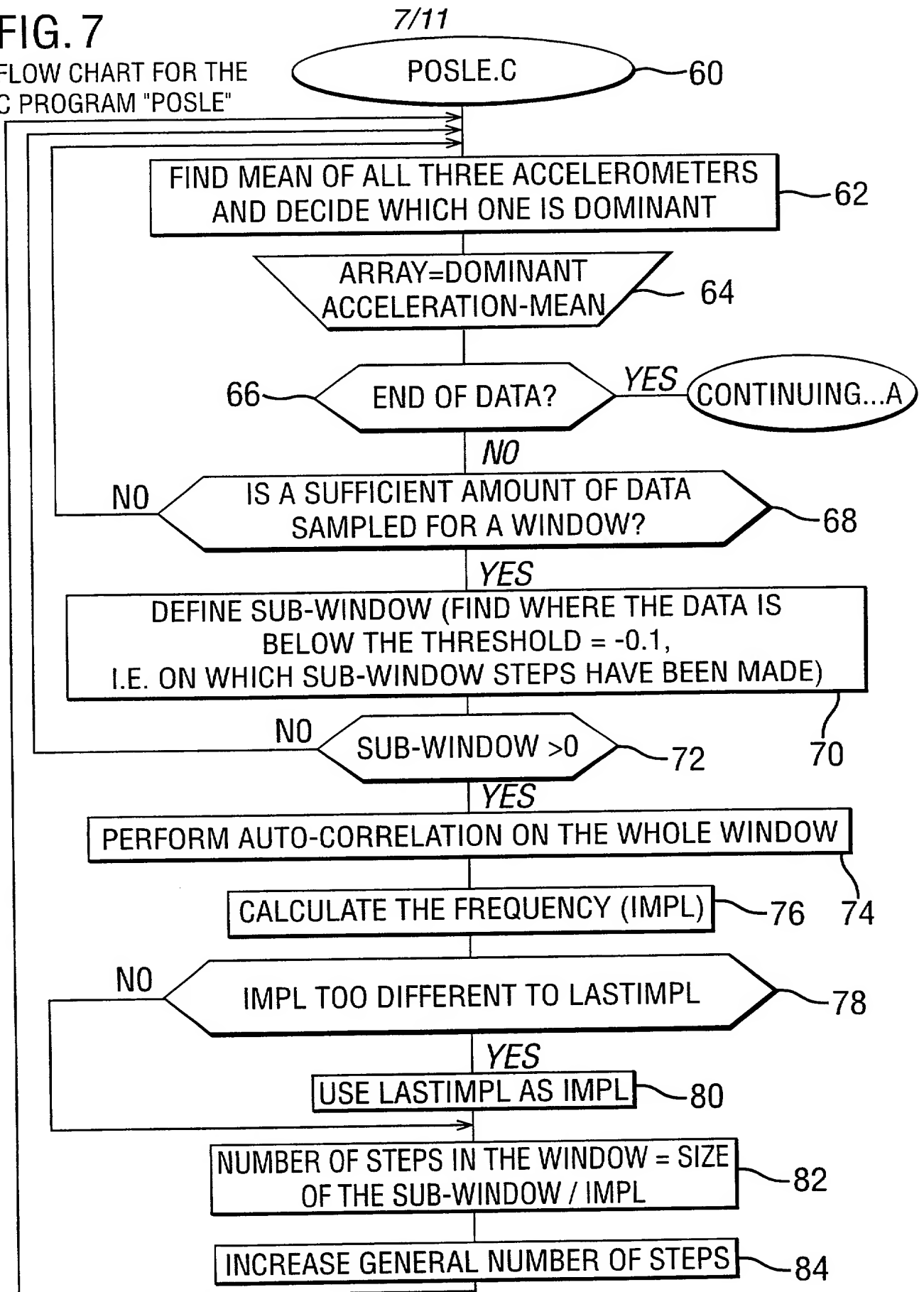


FIG. 7

FLOW CHART FOR THE
C PROGRAM "POSLE"



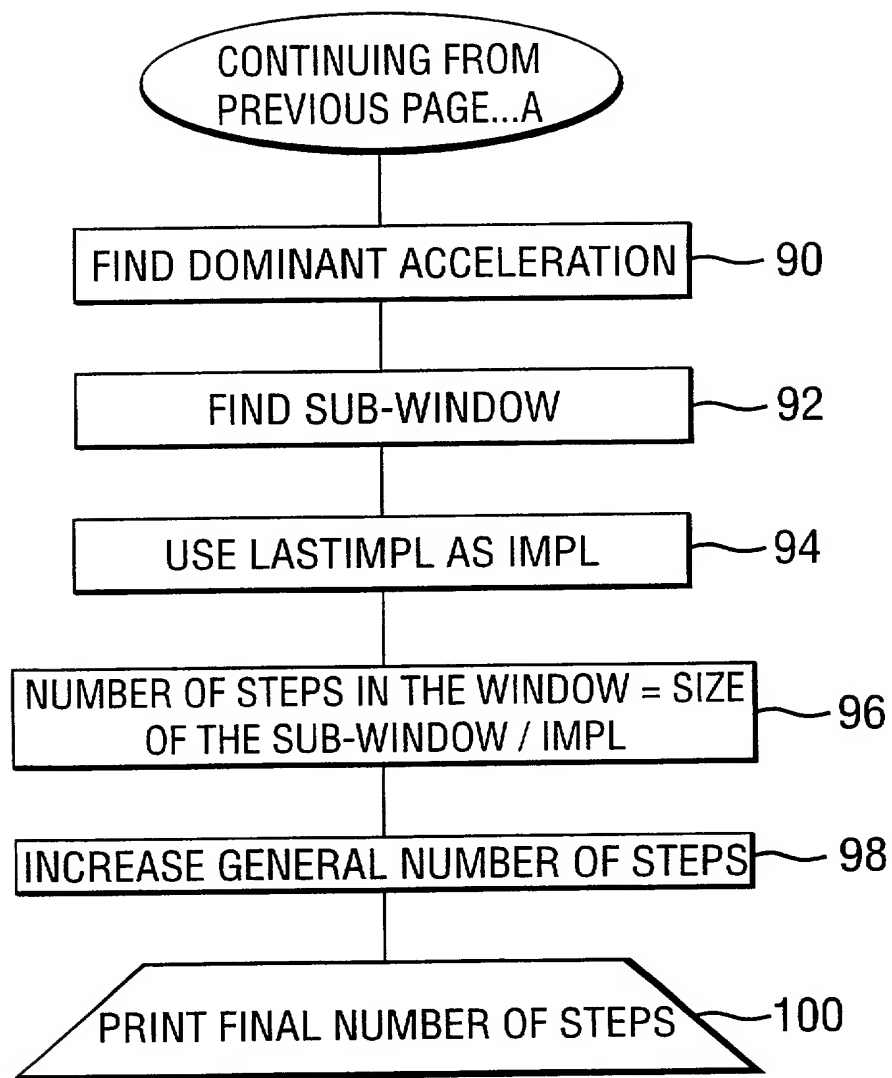


FIG. 7(continued)

FIG. 8

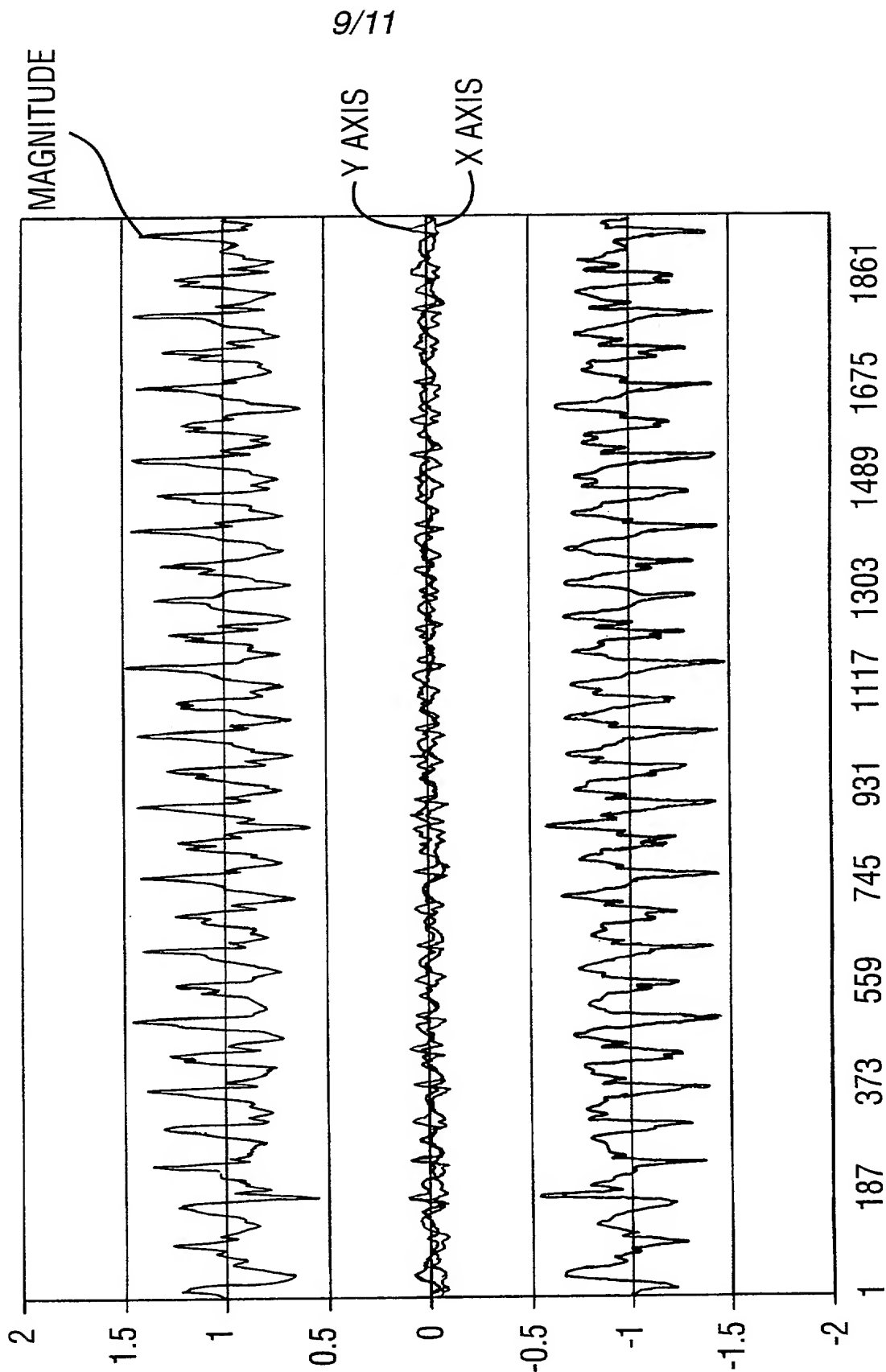
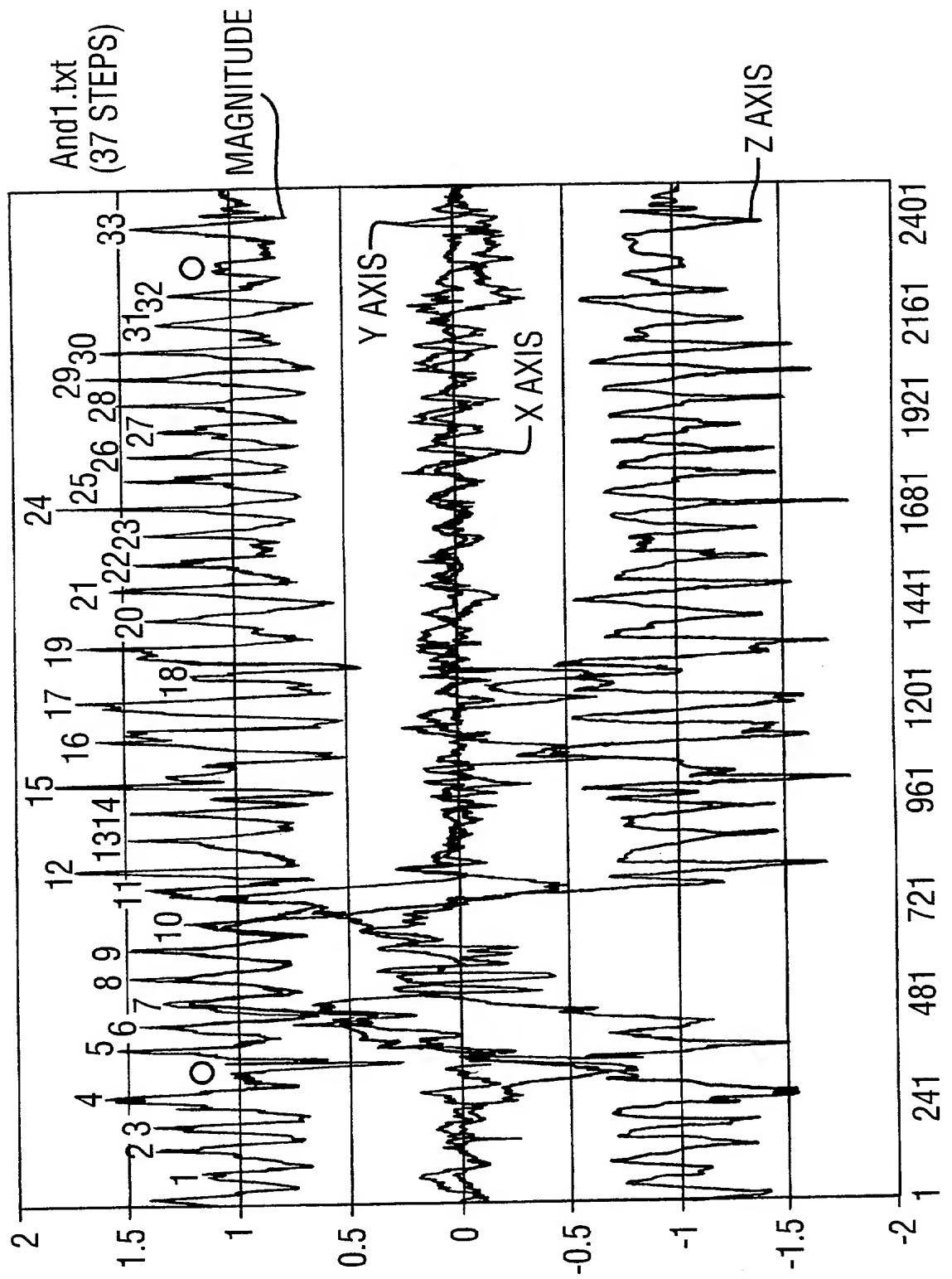
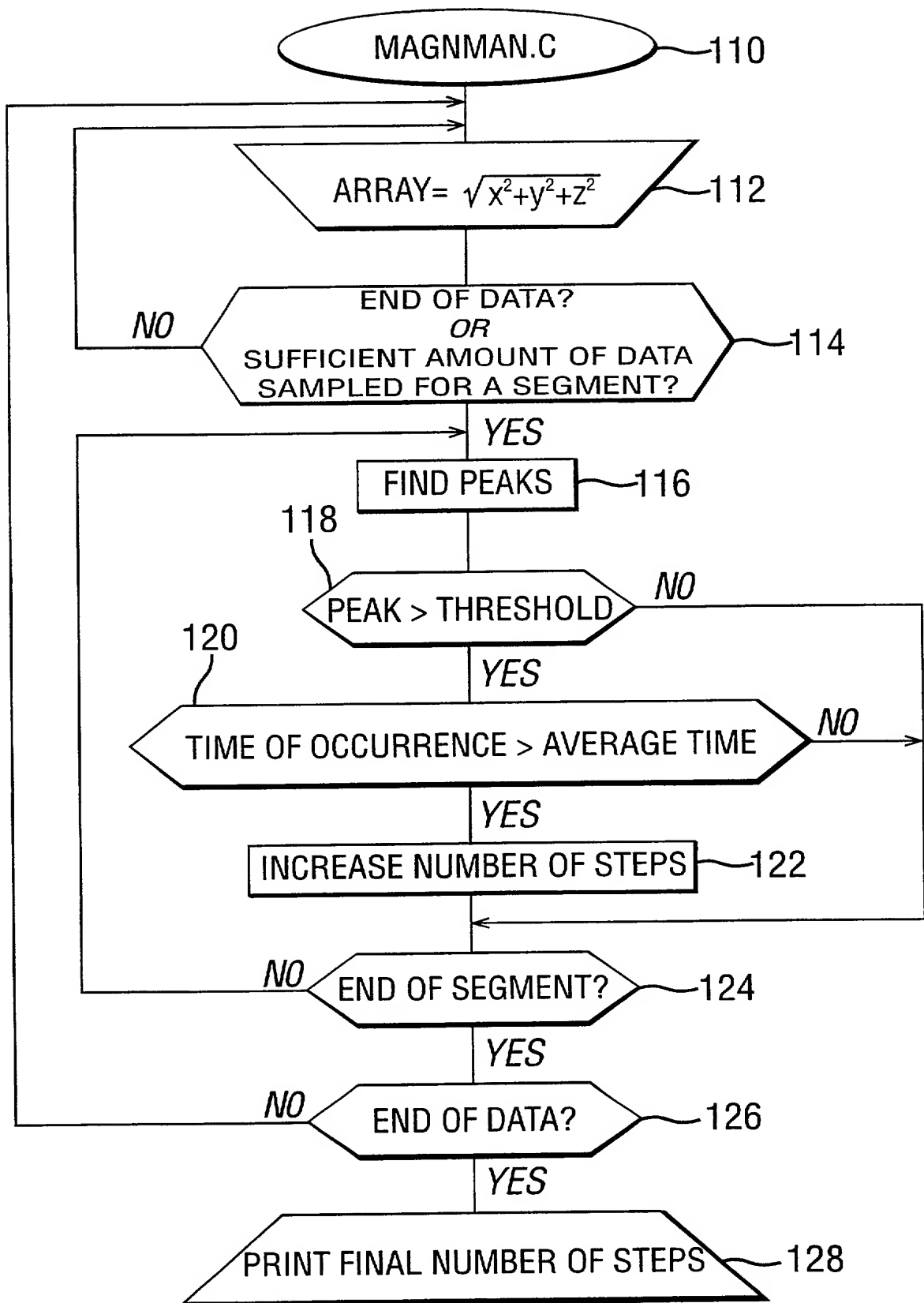


FIG. 9



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FIG. 10



**ELECTRONIC PEDOMETER, EXPECTED BEHAVIOUR DETECTOR AND
SECURITY SYSTEM INCORPORATING SUCH A DETECTOR**

The present invention relates to an electronic pedometer, a expected behaviour detector and to a security system incorporating such a detector. The expected behaviour detector may also be incorporated within supervision apparatus for monitoring the continued functioning of equipment.

According to a first aspect of the present invention there is provided an electronic pedometer, the pedometer being incorporated in an object carried by a person, the pedometer including a plurality of motion detectors, arranged with their measurement axes non-parallel to one another, processing means responsive to the motion detectors for identifying a component of motion in a substantially vertical direction and for analysing that component so as to count steps.

Preferably the motion detectors are accelerometers.

Preferably three mutually orthogonal accelerometers are used. This means that the object is capable of detecting a vertical component of motion due to steps being taken irrespective of the orientation of the object.

The data processor may simply select or weight most heavily the accelerometer having an output which has the largest amplitude of signal or the one which has the largest static component on it's output - the static component being due to the earth's gravitational field. Alternatively the outputs of all of the sensors may be summed or averaged, for example as a geometric sum (the outputs are squared, added and then the sum may optionally be square-rooted).

According to a second aspect of the present invention there is provided an expected behaviour detector comprising:

Input means for gathering data representative of the performance of a specified task or system;

Data processing means for analysing data from the input means; and

Memory means for storing one or more of operational profiles and data representing expected behaviour, the data processor being arranged to compare the data gathered from the input means with the data representing the expected behaviour or system profile, and to make a result of the comparison available.

It is thus possible to provide a expected behaviour detector which is capable of analysing input data, to identify traits or characteristics representative of a user or apparatus being monitored by the detector, to compare these with a library of registered users or expected characteristics or expected events, and to make a result of the comparison available.

Preferably the input means comprises at least one motion detector.

Preferably the input means comprises an accelerometer. The accelerometer may have one or more axes of detection, and preferably is a three axis accelerometer in which the axes are mutually orthogonal.

Additionally or alternatively the input means may comprise a rotation or a direction detector, for example in the form of a gyroscope, having one or more axes of measurement. Preferably the rotation detector has three orthogonal axes of measurement.

Preferably signals from the detector or detectors are processed to select, enhance or suppress features within the signals. The signals may be recorded, or at least buffered, such that a record of motion over a predetermined period is available for analysis or later review.

For a multiple axis accelerometer, the outputs of the accelerometer sensors may be analysed to see which is nearest the vertical and the signal from the sensor may be

enhanced or given more significance than the other sensors when looking for motion of the item containing the accelerometers.

For items which may be inadvertently or deliberately turned such that they are not longer the “right way up” or for items which are normally used in multiple orientations the outputs of the transducers may be combined, for example geometrically summed, in order to create a scalar measurement of acceleration. The static effect of the gravitational field may then be subtracted from the combined output, if desired, to obtain an estimate of acceleration.

Although the two methods described hereinabove for allowing measurements to be made when an item containing the accelerometer (or indeed another multiple axis sensor) is not the correct “way up” are different, these methods may be simultaneously implemented and a decision may be taken as to which seems to be the most reliable under the circumstances.

Given that the signals from the sensors contain noise, and that the signal to noise ratio may vary, the signals may be subjected to filtering or gain control. Such modification may be done in real time or near real time on the signals. Additionally or alternatively the signals may be buffered or stored and processed on a test basis to see which processing option seems appropriate. The data may then be processed on the basis of that option. Thus a data processor may examine the results obtained from selecting one sensor only and compare those with the result of combining the outputs of the sensors. If the apparatus is trying to establish a measurement of vertical acceleration in an environment where horizontal motion is being induced or occurring naturally then the combination of sensor outputs may exhibit degraded performance compared to using a single output of one sensor, provided that sensor is oriented near to the vertical direction.

Similarly an item may be subjected to vigorous movement, where some sensors may reach their limits of reliable operation, or the item may be moved very carefully such that the output of a sensor is zero or comparable to its noise level. Thus gain control and or low pass or band pass filtering may be appropriate.

The signal processing may, for example, include steps of auto-correlation and/or cross-correlation and/or curve fitting. Additionally or alternatively frequency domain analysis of the signals may be performed. Thus, for example, the signals may be converted to the frequency domain by a fourier or laplace transform. This processing can emphasise repeated or rhythmical motion. Examples of such motion occur when a user is walking or running, or when a mass is supported on a spring. Thus, for example, a system implemented within an article which is carried, such as a security box, although it applies equally to other items which are carried, can be arranged to identify when it is in motion and/or the number of steps being taken by the person carrying the article. The system may then further identify a registered user by his characteristic walk, or might monitor the performance of a system, such a car suspension, in order to determine whether it is functioning properly or whether one or more components have degraded unacceptably or become damaged. Similarly, such a system could monitor vibrations of an engine to detect bearing wear, component fatigue or component failure.

The data processor may be arranged to compare the signals, either without or following processing, with one or more characteristic signatures which may be obtained during a learning phase. Such characteristic signatures may be representative of the walking style of an associated one of the one or more registered users, or may represent the vibrational profile of a machine being monitored by an apparatus constituting an embodiment of the present invention. The data processor may implement a neural network which is trained to recognise authorised individuals.

The data processor may be arranged to identify each step in a chain of steps. Alternatively or additionally the data processor may be arranged to identify the steps where the left foot impacts with the ground separately from steps where the right foot impacts with the ground. Although this may allow asymmetric walks to be identified and processed, it is not necessary to identify which foot is which, it is merely sufficient to be able to discriminate between them. This can be advantageous since some individuals apply different pressure to each foot, for example because of a limp or similar. Identification of separate overlapping pulse trains in this way may improve discrimination between motion due to walking and noise due to other forms of motion, such as rotation.

In a prototype embodiment of the invention, a cash-in-transit container was modified to include a three axis accelerometer, memory means and data processor. The data processor was arranged to interface with the cash-in-transit container's security system in order that it could control detonation of the spoiling means (such as a dye pack) contained within the box in order to spoil the contents thereof in the event of an attack on the security container.

A particular problem faced by cash-in-transit containers is that the guard may be attacked and the container may be carried away by a thief, or that the guard may be an accomplice to the theft and may deliberately carry the container in the wrong direction. The present invention can be programmed with data representative of the guard's characteristic walk such that it can identify when it is being carried by the correct person. It can also be loaded with data representative of the expected route taken by the guard from the delivery vehicle to the delivery point. It is thus possible to provide a security system which can detect when an unregistered or non-authorised user is carrying the security box, and can also make a determination as to whether the security box is being carried along the correct route. The apparatus may also detect certain features along a route, such as corners, ascents or descents and stairs by the variation in the users walk, or by looking for other characteristic patterns in the motion sensor output.

The applicant has found that the characteristic walk of an individual is distinct from the walk of others. Thus embodiments of the present invention may be included within portable equipment in order to prevent that equipment from operating if it is carried by an unauthorised user. Examples of such equipment include mobile phones and portable computers. Thus if one of these devices is stolen by a thief, a device will monitor the motion of a thief, determine that it does not correlate with the motion of its expected user, and assert a warning or security signal, and/or invoke a security shut down procedure. The device can be arranged to remain in a secure shut down mode until such time as an authorisation code or other identification is entered on a key pad or other input device, or the device has been carried by the authorised user for a sufficient period with the authorised user's characteristic motion to be identified, confirmed to an acceptable degree of accuracy, and then used to re-invoke operation. Alternatively, the user may program a predetermined sequence of motions or key presses in order to invoke operation of a device incorporating a

behaviour detector constituting an embodiment of the present invention. It should be noted that this technology can be applied to any portable item where it is desirable that it should work for one or more authorised users and be inoperative in the event that it should be obtained by an unauthorised user.

The device may also be arranged to determine when, for example, a guard is running and may use this to infer that an attack is in progress since the guard does not normally run. The associated security mechanism may then be primed or activated. Similarly the device can also deduce when it is being moved by a vehicle, based upon the detected motion of the vehicle's body. Analysis may also be made of the terrain over which the vehicle is travelling. Indeed, embodiments of the present invention may be installed in vehicles to monitor vehicle geometry and suspension performance in order to deduce that a component is wearing out or has failed, or to provide data to active suspension systems so that the suspension can be optimised for the load carried by the vehicle with regard to the terrain and comfort and/or handling required.

The data processor may comprise a neural network or other trainable data system which learns to identify individuals from their walking styles, or other patterns of motion.

The data processor may be responsive to a signal formed from a combination of the sensor outputs. The signal may, optionally, be subjected to further signal processing to normalise the amplitude and/or to remove a 'cleaned' version of the step pattern, for example a sinusoid at the step frequency or a step frequency for part of the signal space local to a region being analysed, so as to emphasise the rapid fluctuations in the signal or deviations from the sinusoid which may carry important information and aiding the identification of step patterns belonging to different individuals.

The present invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 schematically illustrates a security container incorporating a characteristic motion detector constituting an embodiment of the present invention;

Figure 2 is a plot of accelerometer output versus sample number for the security container being carried by a first user;

Figure 3 is a plot of accelerometer output versus sample number for the security container being carried by a second user;

Figure 4 is a plot of the result of performing auto-correlation on the data shown in Figure 3;

Figure 5 shows the result of cross-correlation between the auto-correlated data shown in Figure 4 and a user signature for the second user walking at normal pace;

Figure 6 is a flow chart for a step counting algorithm for determining how far a user has carried the container;

Figure 7 shows an alternative step counting method;

Figure 8 illustrates the individual outputs of X, Y and Z axis accelerometers for an object carried such that the Z axis was vertical;

Figure 9 shows traces from X, Y and Z axis accelerometers for an object which was tumbled whilst it was carried; and

Figure 10 is a flow diagram of a further step counting algorithm constituting an embodiment of the present invention.

A security container, for example a cash-in-transit container is schematically illustrated in Figure 1. The container, generally designated 1, includes a characteristic motion detector 2 constituting an embodiment of the present invention, and a spoiling apparatus 4 of a known design for protecting and spoiling bank notes or the like carried in a secure space 6 within the container 1. The characteristic motion detector 2 comprises a three axis accelerometer 10 having accelerometer outputs connected to analogue inputs of a data processor 12. The data processor 12 is connected to a memory 14 which stores operating instructions for the

data processor 12 together with signatures representative of the guard's characteristic walk and data representative of the drop-off destinations, expected time of drop-off, and expected duration of walk for the guard between a cash-in-transit delivery vehicle and the bank's or other institution's safe or automatic teller machine.

In use, the characteristic motion detector is provided with a real time clock and information concerning the drop-off destinations. Once the security container 1 has been removed from the cash-in-transit vehicle, following any necessary negotiations between security systems to enable the cash-in-transit container to leave the vehicle, the characteristic motion detector then monitors the motion of the box to determine that it is being carried by the correct guard, and also that the expected route is being followed. In order to do this, the characteristic motion detector counts the number of steps taken by the guard and can use this to infer the distance travelled by the box. If, as a result of the calculations carried by the data processor, it determines that the container 1 is being carried by the wrong person, or that this person has travelled too far, or not far enough in the allocated time. The data processor may then assert a signal to the spoiling system 4. The spoiling system 4 may then operate to spoil the contents of the container immediately, or may issue an alert to the guard in order for him to input an override code, or to indicate that he only has a short period of time to get the cash-in-transit container 1 to its destination, or to its start point, in order to inhibit detonation of the spoiling system after this time period.

In theory, adequate data capture could be obtained using a single axis accelerometer monitoring motion in the vertical direction an example of such a trace is shown by the "Z axis" trace in Figure 8. However, in order to defeat such systems, a guard or thief might deliberately carry the container on its side. Additionally, a detector constituting an embodiment of the present invention may be provided in the apparatus which, in use, may be carried in two or more orientations. In order to overcome this problem the outputs of the three accelerometers can be combined, for example using vectorial summation, in order to derive a measurement of acceleration along a predetermined direction. The predetermined direction preferably is the vertical axis and this may be calculated by looking for the effect of the static gravitational field of the earth. In the case where the container is held truly vertical, this corresponds solely to the output of the Z axis

accelerometer. Alternatively, the accelerometer outputs can be examined to see which one is nearest vertical, and this one selected. The sensor having the biggest output due to the earth's gravitational field is the nearest one to vertical.

Figure 2 shows a trace of the output from the Z axis accelerometer for a first users walk with a cash-in-transit container vertical. Figure 3 shows a similar plot for a second user walking and carrying the cash-in-transit container. Although the abscissae of the Figures are at different scale (because they represent different time intervals), it is nevertheless evident that the plots have a different form and this can be used to identify the characteristic motion of the user. Analysis can be performed in the time or frequency domains. The analysis is relatively simple if it is performed in the frequency domain. Firstly, the output of the accelerometer (or the combined output of the accelerometers) is buffered and then subjected to auto-correlation. Figure 4 shows the result of auto-correlation of the wave form shown in Figure 3. It can be seen that the wave form is well defined up to approximately sample 14000. If auto-correlation is done without boundaries then the samples degrade. Results can be improved if time limiting of the results is implemented.

The auto-correlation effectively cleans and averages the signal and allows a signature pulse train representative of the persons characteristic walk to be generated in the time domain. Once the signature train is calculated, it is then cross correlated with the original input signal.

One might assume that the period for the pulse train (obtained as a result of the auto-correlation) should be the same for the same person. However, this is not correct. Although the person's characteristic walk remains approximately the same, nevertheless the period of the pulse train is affected by the person's walking speed. The person may vary their walking speed slightly, and for this reason it is undesirable to estimate the pulse train frequency in advance. In fact better results are obtained if the sampled data is auto-correlated in near real time, the auto-correlation is then used to calculate the period for the pulse train which is then used for cross-correlation. The cross-correlation would be performed retrospectively, but still in near real time.

Figure 5 illustrates the result of the cross-correlation between the input data and the pulse train obtained from analysis of the auto-correlated data. It will be seen that from samples 1 to approximately 12000 the wave form shape remains well determined. In the sample range from sample 13000 to approximately 17000 the wave form shape starts to evolve and becomes double-peaked as the signal counting moves out of phase with the reference signal. At approximately sample 19000 the user stops walking, and the output becomes the result of cross correlation with the “noise” of a user holding the container.

The steps of auto and cross correlation can be omitted in order to implement a simpler system. Figure 6 illustrates a routine for counting the number of steps taken without using correlation. The programme commences at step 30, from where control is passed to step 32 where an input data file is read in. It has been found that the start of the data may contain large amplitude spurious signals resulting from picking the box up and consequently the first few samples of the data are discarded at step 34. Control is then passed to step 36 which searches for negative peaks in the data. Once the peak is found, it is compared with a predetermined threshold value. If the magnitude of the peak exceeds the threshold, control is then passed to step 38 to check that the period between the current peak and the preceding peak is greater than 50% of the time period occurring between the preceding peak and the peak preceding that one. This check is omitted for the first couple of peaks. If this condition is satisfied, control is then passed to step 40 where the number of steps is incremented and step 42 where the value is saved. Control is then passed to step 44 where the most recent peak values are examined and the threshold is then reset to 80% of the magnitude of the smallest acceptable peak. Control is then passed to step 46 which checks if any negative peak can be counted as a step using the new threshold. The step number is then calculated again at step 48.

The accelerometer data can also be “cleaned” by low pass filtering and/or curve fitting. Thus, for example, a least squares fitting algorithm may be used, either on a segment by segment basis, or on a sliding basis to so as to reduce the effects of noise.

In a further embodiment of the present invention a curve fitting technique was used to smooth the data.

In the implementation of this, data was sampled from the accelerometer by taking the geometric sum of its X, Y and Z outputs.

$$\text{Output} = (X^2 + Y^2 + Z^2)^{1/2}$$

The output may include a large static component due to gravity which moves the average value of the output well away from zero. However, corrected accelerometers may be used, where the static gravitational force is nulled out at the sensor - but this may result in the introduction of large static signals when the sensor is tilted away from vertical.

The sampled data was then thinned by :

1. choosing every 10th data sample;
2. fitting a curve to the first 7 data parts;
3. incrementing position along the curve;
4. repeating steps 2 and 3 seven times;

This concludes one segment.

5. on the segment, find a concave group; ie a positive turning point;
6. increment a count of the number of steps; and
7. repeat step 6 for all concave groups of the segment.

This is repeated as often as necessary to determine the number of steps taken.

Figure 7 illustrates a further method for counting the number of steps taken. Auto-correlation is used in this example. The program commences at step 60, from where control is passed to step 62 where the output of the accelerometers are compared to see which one is dominant. The dominant accelerometer, ie the one nearer the vertical axis, will have the highest static component due to gravity evident on its output. This accelerometer is then selected and control passed to step 64 where data from that accelerometer is buffered into an array and the mean acceleration is removed from the data

(ie the earth's static gravitational component) in order to bring the data around the zero axis. Control is then passed to step 66 where the size of the array is tested to see whether sufficient data is in it and/or to see if an end of file marker had been reached. If sufficient data is not in the array, control is passed to step 68 where a test is made to see if there is sufficient amount of data in the array for a sample window to be formed. The size of the window is somewhat arbitrary and can be varied, optionally by the program, but in testing has been set to be equivalent to a period of 5 seconds. If there is insufficient data, control is returned to step 62, otherwise control is passed to step 70. Step 70 defines a sub-window within the array, when the signal represented by the data is in excess of a predetermined magnitude, control is then passed to step 72 where a test is made to see that one entire sub-window has data in it. If a sub-window has not been defined (ie is not full of data) control is passed to step 62 otherwise control then passes to step 74. Step 74 performs auto-correlation on the whole window and the result of the auto-correlation is passed to step 76 where a step frequency, IMPL is calculated. Control is then passed to step 78 where the value of IMPL as calculated at step 76 is compared with a previous estimate of IMPL, in order to determine if they are sufficiently close to one another. If they are sufficiently close, control is passed to step 82. If the differences between current and previous versions of IMPL are too great, control is passed to step 80 where the previous value for IMPL is substituted in place of the current one. Step 82 calculates the number of steps in the window by dividing the time period for which the window spans by the step frequency. The result of this calculation is then added to a total of the number of steps taken held at step 84. Control is then returned to step 62. Once the end of data is reached at step 66, control is passed to step 90 where the dominant acceleration is determined as described hereinabove. Control is then passed to step 92 which finds a sub-window and then to step 94 which uses the previous value of IMPL as a current value of IMPL. Control is then passed to step 96 which calculates the number of steps in a window thereby dividing the temporal extent of the window by the step frequency, the result of this is added to a count of the number of steps by step 98 and the total number of steps is output at step 100.

Figure 8 illustrates the signals received from the X axis, Y axis and Z axis accelerometers where the Z axis accelerometer was nominally aligned with the vertical whilst an object

including these accelerometers was carried. The output of the Z axis accelerometer includes a large static component due the earth's gravity which causes trace from this accelerometer to be centred about the minus 1 line on the abscissa. It can be seen that the outputs of the X and Y axis accelerometers are relatively small and bear little correlation with the output from the Z axis accelerometer. The result of a geometric combination of the outputs of these accelerometers, where the output of each accelerometer is squared, then summed and the square root taken, gives rise to the trace labelled magnitude also shown on this graph. In this instance the wave form of the "magnitude" trace is highly correlated with that of the Z axis accelerometer output.

Figure 9 illustrates a comparable trace where the object having the accelerometers therein was deliberately tumbled as it was carried, especially during the interval between samples 240 and 800. Nevertheless, it can be seen that the magnitude trace contains clearly identifiable peaks allowing the number of steps to be estimated. In this example, 37 steps were taken and 33 were identified in the magnitude trace.

Figure 10 is a flow diagram for a procedure for analysing the signals from the accelerometers in order to obtain the results as shown in Figure 9. The procedure starts at step 110. From here, control passes to step 112 where the sampled values of the X axis, Y axis and Z axis accelerometers are squared, added and then square-rooted to obtain a geometric mean which is then written to a file. Control is then passed to step 114 where the size of the file is examined see if an end of file marker has been reached or there is sufficient amount of data in the file for a period of motion to be analysed. If either of these tests fail, control is then passed back to step 112. If this test is passed control is passed to step 116 where a portion of the data is scanned in order to identify the peaks therein. Control is then passed to step 118 which checks to see whether the magnitude of the peak exceeds a threshold value. If the size of the peak exceeds the threshold control is passed to step 120, otherwise control is passed to step 124. Step 120 checks to see that the time difference between the most recently located peak and the previously located peak is greater than a threshold value "average time". If this test is satisfied, control is passed to step 122 where the number of steps counted is incremented, otherwise control is passed to step 124. From 122 control is passed to step 124 which checks to see whether an end of a

segment has been reached. If the end of a segment has not been reached, control is returned to step 116 otherwise control is passed to step 126. A test is performed in step 126 to see whether the end of the data has been reached. If the end of the data has been reached, control is passed to step 128 which makes available as an output the final number of steps taken, otherwise control is passed to step 112.

It is thus possible to examine the data to determine the number of steps taken by the security guard, and hence to infer how far he has travelled during the time period since the monitoring began. This can be used to determine whether the guard is walking in the correct direction since any distance too great or too small at the end of an expected time period for the task can be used to infer whether an attack or attempted theft is in progress.

Further embodiments of the invention may be incorporated within mobile telephones or mobile computers in order to act as user verification either by monitoring the user's walk or possibly by monitoring a tap or shake sequence which the user has identified to the device as being a user identity code.

Claims

1. An electronic pedometer, the pedometer being suitable for inclusion in an object carried by a person, the pedometer including a plurality of motion detectors arranged with their measurement axes non-parallel to one another, and processing means responsive to the motion detectors for identifying a component of motion in a substantially vertical direction and for analysing that component so as to count steps.
2. An electronic pedometer as claimed in claim 1, in which the motion detectors are accelerometers.
3. An electronic pedometer as claimed in claim 2, in which first, second and third non-parallel accelerometers are provided for measuring motion in three directions.
4. An electronic pedometer as claimed in claim 3, in which the first, second and third accelerometers are mutually orthogonal.
5. An electronic pedometer as claimed in claims 2, 3, or 4, in which the processing means selects the accelerometer having the largest amplitude signal.
6. An electronic pedometer as claimed in any one of claims 2, 3 or 4, in which the processing means examines the outputs of the accelerometers and selects the one with the largest static component as the output signal.
7. An electronic pedometer as claimed in any one of claims 2 to 4, in which the outputs of the sensors are summed or averaged.
8. An electronic pedometer as claimed in any one of the preceding claims, in which the signals from the motion detectors are processed to select, enhance or suppress features within the signals.

9. An electronic pedometer as claimed in any one of the preceding claims, in which the signals from the motion detectors are recorded or buffered such that a record of motion over a predetermined period is available for analysis.
10. An electronic pedometer as claimed in any one of the preceding claims, in which the outputs of the sensors are subjected to gain control and/or filtering.
11. An electronic pedometer as claimed in any one of the preceding claims, in which the processing of the signals from the motion detectors includes the steps of cross-correlation and/or auto-correlation, and/or smoothing and/or curve fitting so as to emphasise repeated or rhythmical motion.
12. An electronic pedometer as claimed in any one of the preceding claims in which the signals from the sensors, either individually or when combined, are converted to the frequency domain.
13. An electronic pedometer as claimed in any one of the preceding claims, in which the pedometer includes a data processor for recognising an individual from their walk.
14. An electronic pedometer as claimed in claim 13, in which the data processor is or simulates a neural network.
15. An electronic pedometer as claimed in claim 13 or 14, in which the data processor analyses the signals to identify two interleaved signals, one resulting from movement of the left leg and one resulting from movement of the right leg.
16. An electronic pedometer as claimed in any one of the claims 13 to 15, in which the pedometer invokes a warning or security signal when it is undergoing motion which does not correspond to that of an authorised user.

17. An electronic pedometer as claimed in claim 16, in which the electronic pedometer inhibits the warning or security signal once a user code has been entered, the device has been carried by an authorised user for a predetermined time period or the user undertakes a predetermined series of motions.
18. An item of portable equipment including an electronic pedometer as claimed in any one of the preceding claims.
19. A cash in transit container including an electronic pedometer as claimed in any one of the preceding claims.
20. A cash in transit container as claimed in claim 19, in which the motion of the container is monitored in order to determine if a person carrying the container is running such that a signal can be supplied to a security system when the person is running.
21. An expected behaviour detector, comprising input means for gathering data representative of the performance of a specified task or system;

a data processor for analysing data, and

memory for storing one or more of operational profiles and data representing expected behaviour, the data processor arranged to compare data gathered from the input means with the data representing the expected behaviour or system profile, and to make the result of the comparison available.
22. An expected behaviour detector as claimed in claim 21, wherein the input means comprises at least one motion detector.
23. An expected behaviour detector as claimed in claim 22, wherein the at least one motion detects is an accelerometer or a rotation detector.

24. An expected behaviour detector as claimed in claim 22, wherein the data representing expected behaviour relates to the performance of a system and the expected behaviour detector monitors said system confirm that the system is functioning correctly and to signal that this is or is not so.

CLAIMS

1. An electronic pedometer, the pedometer being suitable for inclusion in an object carried by a person, the pedometer including a plurality of motion detectors arranged with their measurement axes non-parallel to one another, and processing means responsive to the motion detectors for identifying a component of motion in a substantially vertical direction and for analysing that component so as to count steps, and further arranged to compare the number of steps taken with a predetermined expected number and/or to compare the characteristic motion an authorised user with that of the actual motion of the person carrying the object, and to assert a warning if the number of steps exceeds the expected number or the motions do not match.
2. An electronic pedometer as claimed in claim 1, in which the motion detectors are accelerometers.
3. An electronic pedometer as claimed in claim 2, in which first, second and third non-parallel accelerometers are provided for measuring motion in three directions.
4. An electronic pedometer as claimed in claim 3, in which the first, second and third accelerometers are mutually orthogonal.
5. An electronic pedometer as claimed in claims 2, 3, or 4, in which the processing means selects the accelerometer having the largest amplitude signal.
6. An electronic pedometer as claimed in any one of claims 2, 3 or 4, in which the processing means examines the outputs of the accelerometers and selects the one with the largest static component as the output signal.
7. An electronic pedometer as claimed in any one of claims 2 to 4, in which the outputs of the sensors are summed or averaged.

8. An electronic pedometer as claimed in any one of the preceding claims, in which the signals from the motion detectors are processed to select, enhance or suppress features within the signals.
9. An electronic pedometer as claimed in any one of the preceding claims, in which the signals from the motion detectors are recorded or buffered such that a record of motion over a predetermined period is available for analysis.
10. An electronic pedometer as claimed in any one of the preceding claims, in which the outputs of the sensors are subjected to gain control and/or filtering.
11. An electronic pedometer as claimed in any one of the preceding claims, in which the processing of the signals from the motion detectors includes the steps of cross-correlation and/or auto-correlation, and/or smoothing and/or curve fitting so as to emphasise repeated or rhythmical motion.
12. An electronic pedometer as claimed in any one of the preceding claims in which the signals from the sensors, either individually or when combined, are converted to the frequency domain.
13. An electronic pedometer as claimed in any one of the preceding claims, in which the pedometer includes a data processor for recognising an individual from their walk.
14. An electronic pedometer as claimed in claim 13, in which the data processor is or simulates a neural network.
15. An electronic pedometer as claimed in claim 13 or 14, in which the data processor analyses the signals to identify two interleaved signals, one resulting from movement of the left leg and one resulting from movement of the right leg.



16. An electronic pedometer as claimed in any one of the claims 13 to 15, in which the pedometer invokes a warning or security signal when it is undergoing motion which does not correspond to that of an authorised user.
17. An electronic pedometer as claimed in claim 16, in which the electronic pedometer inhibits the warning or security signal once a user code has been entered, the device has been carried by an authorised user for a predetermined time period or the user undertakes a predetermined series of motions.
18. An item of portable equipment including an electronic pedometer as claimed in any one of the preceding claims.
19. A cash in transit container including an electronic pedometer as claimed in any one of the preceding claims.
20. A cash in transit container as claimed in claim 19, in which the motion of the container is monitored in order to determine if a person carrying the container is running such that a signal can be supplied to a security system when the person is running.
21. An expected behaviour detector, comprising input means for gathering data representative of the performance of a specified task or system;
a data processor for analysing data, and
memory for storing one or more of operational profiles and data representing expected behaviour, the data processor arranged to compare data gathered from the input means with the data representing the expected behaviour or system profile, and to make the result of the comparison available.
22. An expected behaviour detector as claimed in claim 21, wherein the input means comprises at least one motion detector.

23. An expected behaviour detector as claimed in claim 22, wherein the at least one motion detects is an accelerometer or a rotation detector.
24. An expected behaviour detector as claimed in claim 22, wherein the data representing expected behaviour relates to the performance of a system and the expected behaviour detector monitors said system confirm that the system is functioning correctly and to signal that this is or is not so.





INVESTOR IN PEOPLE

Application No: GB 0022857.7
Claims searched: 1 to 20

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Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK CI (Ed.S): G1N (NACNR) G4N (NCM)
Int CI (Ed.7): G01C 22/00 G08B 13/14
Other: Online: WPI; EPODOC; JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	US 5955667 (FYFE)	1, 2, 7, 8, 9, 10, 13, 18 at least
X	US 4337462 (LEMELSON) see column 1 lines 60-63 and column 2 lines 31-68	1 to 4, 7, 8, 9, 18, 19 at least
X	IEEE Transactions on Instrumentation and Measurement, Vol 44, No 3, June 1995, K Aminian, "estimation of speed and incline of walking using neural network", pages 743-746	1 to 11, 13, 14, 18 at least

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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